60. (*New*) An MRI system for obtaining an image relating to fluid within an object, in which the object placed in a static magnetic field is subjected to a scan based on a pulse sequence including a readout gradient pulse, comprising:

a time phase setting unit configured to set a cardiac time phase of the object;

a scanning unit configured to perform the scan at the cardiac time phase to acquire an echo signal from the object under a condition that an applied direction of the readout gradient pulse is substantially in accordance with a moving direction of the fluid in motion within the object; and

an image producing unit configured to produce, from the echo signal, the image relating to the fluid.--

REMARKS

Upon entry of this amendment, claims 5-23, 25-31, 36-51 and 53-60 are pending. By the present amendment, claims 1-4, 24, 32-35 and 52 have been canceled without prejudice, claims 5-12, 14-16, 18-21, 23, 25, 27-31, 36-43, 45-51, 53, 54 and 56 have been amended for clarity and new claims 57-60 have been added.

Applicants appreciate the Examiner's indication that claims 4-9, 12 and 13 would be allowable if rewritten in independent form. New independent claims 57 and 58 substantially incorporate the patentable features of claim 4. As such, claims 57, 58 and the claims depending therefrom (claims 5-12, 15, 16 and 18) are allowable, and no further comment will be made with respect thereto. It is also noted that independent claims 14 and 51 also recite the patentable features of claim 4 and the intervening claims

from which original claim 4 depends, namely that the imaging scan comprises a first scan starting at one of the two cardiac time phases falling in the systole and a second scan starting at the other of the two cardiac time phases falling in diastole, both of the first scan and the second scan being based on a half-Fourier technique. Therefore, it is respectfully submitted that for at least the same reason as claim 4 is allowable, claims 14 and 51 are also allowable.

The objection to claim 23 for containing minor typographical informalities is respectfully traversed. Claim 23 has been amended to obviate the objection. Accordingly, reconsideration and withdrawal of the objection are respectfully requested.

The rejection of claims 15, 18-50 and 53-56 under 35 U.S.C. §112, first paragraph is respectfully traversed. Without acquiescing in the rejection, it is noted that claims 24 and 32-35 have been canceled without prejudice, and claims 15, 18-21, 23, 25, 27-31, 36-43, 45-50, 53, 54 and 56 have been amended for clarity. By virtue of the amendments to the claims, the rejection is overcome. Therefore, reconsideration and withdrawal of the rejection are respectfully requested.

The rejection of claims 19 and 49 under 35 U.S.C. §102(b) over O'Donnell (U.S. Patent No. 4,609,872) is respectfully traversed. Without acquiescing in the rejection, claims 19 and 49 have been amended for clarity. Accordingly, the rejection will be discussed with respect to the amended claims.

O'Donnell is directed to NMR multiple-echo phase-contrast blood flow imaging. O'Donnell discloses a method for magnetic resonance imaging of fluid flow, and particularly in vivo blood flow, using multiple-echo phase-contrast sequences of signals both in the magnetic field gradient in the direction in which fluid flow is to be

determined, and in the radio-frequency magnetic field utilized with the magnetic field gradient.

In complete contrast, the claims clearly recite that the applied direction of the readout gradient pulse is substantially in accordance with a moving direction of the fluid in motion within the object. It is the position of the Office Action that the disclosure of O'Donnell at Col. 5, lines 55-65 anticipates the claimed application of a gradient pulse in the direction of blood flow. However, a careful reading of O'Donnell reveals that this is simply not the case. In particular, O'Donnell states "a fluid flow in the Z direction imparts a phase shift proportion to the Gz gradient" (see, *e.g.*, Col. 5, lines 57-58). The Gz gradient of O'Donnell is not a gradient for readout echo data as set forth in the claims. There is no teaching or suggestion in O'Donnell that the readout gradient pulse *itself is applied* in accordance with the blood flow direction.

In distinction, the claims specifically recite *a readout gradient pulse that itself has an applied direction substantially in accordance with a moving direction of fluid in motion within the object.* This is illustrated by way of example in Figure 20 "RO" (see also GR in Figure 18C), and is described, for example, at page 27, lines 5-8 of the specification. This application technique provides numerous advantages heretofore unrealized in the prior art, as set forth, for example, at page 33, lines 1-22 of the specification.

It is axiomatic that in order for a reference to anticipate a claim, the reference must disclose, teach or suggest each and every feature of the claimed invention. As set forth above, O'Donnell fails to disclose, teach or suggest each and every feature of the claimed invention. In particular, O'Donnell fails to disclose, teach or suggest a readout gradient

pulse that itself has an applied direction substantially in accordance with a moving direction of fluid in motion within the object. Accordingly, O'Donnell fails to anticipate the claimed invention. Therefore, reconsideration and withdrawal of the rejection are respectfully requested.

The rejection of claims 1-3, 10, 11, 14, 51 and 52 under 35 U.S.C. §103(a) over Mistretta (U.S. Patent No. 5,830,143, hereinafter "Mistretta") is respectfully traversed. Without acquiescing in the rejection, claims 1-3 and 52 have been canceled without prejudice and claims 10, 11, 14 and 51 have been amended for clarity. Accordingly, the rejection will be discussed with respect to the pending and amended claims.

Mistretta is directed to a gated time-resolved contrast-enhanced 3D MR angiography. According to Mistretta, a dynamic MRA study of a subject is performed using a 3D fast gradient-recalled echo pulse sequence that employs a non-selective RF excitation pulse. The frame rate of the resulting series of reconstructed images is purportedly increased by sampling a central region of the k-space at a higher rate than the peripheral regions of the k-space. The acquisition is gated using a cardiac trigger signal and the central region of the k-space is acquired during diastole and the peripheral regions of the k-space are acquired during systole. Image frames are reconstructed at each sampling of the central k-space region using the temporally nearest samples from the peripheral k-space regions. Two of the image frames are subtracted to form an MR angiogram. There is no teaching or suggestion anywhere in Mistretta of the feature of both the first scan and the second scan being based on a half-Fourier technique.

In complete contrast, the claims specifically recite that both the first scan and the second scan are based on a half-Fourier technique. Moreover, the Office Action admits

that this feature is not present in the cited prior art by virtue of the allowance of claim 4, which specifically recites that the first and second scans are each based on a half-Fourier technique. No reference has been cited to overcome this fundamental deficiency of Mistretta. Accordingly, Mistretta fails to render the claimed invention obvious. Therefore, reconsideration and withdrawal of the rejection are respectfully requested.

The rejection of claims 15-18, 20, 36 and 37 under 35 U.S.C. §103(a) over Mistretta in view of O'Donnell is respectfully traversed. Without acquiescing in the rejection, claims 15, 16, 18, 20, 36 and 37 have been amended for clarity. Accordingly, the rejection will be discussed with respect to the amended claims.

It is respectfully submitted that O'Donnell fails to overcome the deficiencies noted above with respect to Mistretta as applied to claims 15-18. In particular, O'Donnell fails to disclose or suggest that the first and second scans are each based on a half-Fourier technique. Therefore, even if, *arguendo*, the combination of Mistretta and O'Donnell were proper, the combination nevertheless fails to render these claims obvious.

Claims 20, 36 and 37 recite that a readout gradient pulse that *itself* has an applied direction substantially in accordance with a moving direction of fluid in motion within the object. As set forth above, there is no teaching or suggestion of this feature in O'Donnell. The Office Action admits that this feature is not present in Mistretta. Therefore, even if, *arguendo*, the combination of Mistretta and O'Donnell were proper, the combination nevertheless fails to render the claimed invention obvious.

Because the combination of features recited in claims 15-18, 20, 36 and 37 are not rendered obvious by the combination of Mistretta and O'Donnell, reconsideration and withdrawal of the rejection are respectfully requested.

In view of the foregoing, it is respectfully submitted that the entire application is in condition for allowance. Favorable reconsideration of the application and prompt allowance of the claims are earnestly solicited.

Should the Examiner deem that further issues require resolution prior to allowance, the Examiner is invited to contact the undersigned attorney of record at the telephone number set forth below.

Respectfully submitted,

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MARKED-UP VERSION OF AMENDED CLAIMS

5. (*Amended*) The MRI system of claim [4] 58, wherein the first scan is [composed of a scan depending on] is carried out using a pulse sequence generating an echo signal [in order] to map echo data in a central region of a first k-space for producing the image, the central region [forming] corresponding to a lower-frequency region in a phase-encode direction of the first k-space, and

the second scan is [composed of a scan depending on] carried out using a pulse sequence generating an echo signal [in order] to map echo data in [one of] both a central region and one of both end regions other than the central region of a second k-space for producing the image, the central region [forming] corresponding to a lower-frequency region in a phase-encode direction of the second k-space and both of the end regions [forming] corresponding to a higher-frequency region in the phase-encode direction of the second k-space.

6. (*Amended*) The MRI system of claim 5, wherein the image producing [means has] unit includes duplicating means for duplicating echo data existing in one end region of the second k-space to one of both end regions of the first k-space, the one end region of the first k-space being yet to be mapped with echo data, and calculating means for calculating, with regard to each of the first and second k-spaces, additional echo data based on the half-Fourier technique so that the calculated additional echo data [are] is mapped into the remaining end region being yet to be mapped [in each of the first and second k-spaces for each of which the echo data are acquired with the first and second

scans, respectively, and duplicating means for duplicating, into a remaining region of the first k-space in which echo data is not mapped, echo data existing in a corresponding region of the second k-space to the remaining region of the frost k-space].

7. (*Amended*) The MRI system of claim 6, wherein the image producing means includes arterial phase image producing means for obtaining one of echo data and image data representing an arterial phase image [by executing calculation] through a predetermined type of calculation executed between one of echo data of the first k-space and image data thereof and one of echo data of the second k-space and image data thereof.

8. (*Amended*) The MRI system of claim 7, wherein the predetermined type of calculation executed by the arterial phase image producing means is one of subtraction, weighted difference calculation, and addition.

9. (*Amended*) The MRI system of claim 7, wherein the image producing [means] unit includes venous phase image producing means for obtaining one of echo data and image data thereof representing a venous phase image by executing subtraction between one of echo data of image data representing the arterial phase image obtained by the arterial phase image producing means and one of echo data of the second k-space and image data thereof.

10. (*Amended*) The MRI system of claim [1] 58, wherein each of the first and second scans [the MR imaging scan] is either one of a two-dimensional scan and a three-dimensional scan.

11. (*Amended*) The MRI system of claim [1] 58, wherein the [scanning means is composed of means that executes] unit is configured to execute the MR imaging scan with a pulse sequence based on one of [a FASE (Fast Asymmetric SE) technique,] an EPI (Echo Planar Imaging) technique[,] and an FSE (Fast Spin Echo) technique.

12. (*Amended*) The MRI system of claim [2] 58, wherein the time phase setting [means] unit has detecting means for detecting a signal indicative of the cardiac time phases of the object, preparing means for obtaining a plurality of MR images by executing a preparing MR sequence a plurality of times [for a] toward the region to be imaged of the object at different timings from a heartbeat reference wave appearing cyclically in the signal detected by the detecting means, and means for determining the two cardiac time phases from the plurality of MR images obtained by the preparing means.

14. (*Amended*) An MR imaging method of obtaining an image relating to fluid within a region to be imaged of an object, comprising [the steps of]:

setting [a plurality of] two different cardiac time phases falling into a systole and a diastole of a cardiac cycle of [an] the object;

[acquiring a plurality of sets of echo data through an MR imaging scan started at each of the plurality of different cardiac time phases in turn] performing toward the region to be imaged of the object, an MR imaging scan starting in turn at each of the two cardiac time phases to acquire two sets of echo data, the MR imaging scan comprising a first scan starting at one of the two cardiac time phases falling in the systole and a second scan starting at the other of the two cardiac time phases falling in the diastole, both of the first scan and the second scan being based on a half-Fourier technique; and

producing, from the two sets of acquired echo data, the [an] image [of one of] relating to the fluid [residing in a region to be scanned of the object and a parenchymal portion of the object influenced by the fluid from the plurality of sets of echo data].

15. (*Amended*) The MRI system of claim [1] 58, wherein the scanning [means has means for executing] unit is configured to execute a pulse sequence including readout gradient pulse of which applied direction is substantially [parallel to] in accordance with a moving direction of the fluid.

16. (*Amended*) The MRI system of claim 15, wherein the readout gradient pulse has a main pulse [used] for reading out the echo signal and a control pulse [added to the main pulse and used] for controlling behaviors [in phase] of magnetic spins of the fluid concerning a phase of the magnetic spins, the control pulse being added to the main pulse on a time axis thereof.

18. (*Amended*) The MRI system of claim 16, further comprising [means for controlling] a unit configured to control an intensity of the control pulse in accord with a flow velocity of the fluid.

19. (*Amended*) An MRI system [that executes] for obtaining an image relating to fluid of an object, in which the object placed in a static magnetic field is subjected to a scan based on a pulse sequence including a readout gradient pulse [toward an object placed in a static magnetic field], comprising:

scanning [means for performing] unit configured to perform the scan to acquire an echo signal with an applied direction of the readout gradient pulse substantially [parallel to] in accordance with a moving direction of fluid in motion within the object; and

an image producing [means for producing] unit configured to produce, from the echo signal, [an] the image [of one of] relating to the fluid [and a parenchymal portion of the object influenced by the fluid].

20. (*Amended*) An MRI system [that executes] for obtaining an image relating to fluid within an object, in which the object placed in a static magnetic field is subjected to a scan based on a pulse sequence including a readout gradient pulse [toward an object placed in a static magnetic field], comprising:

time phase setting means for setting a cardiac time phase of the object;

scanning means for performing the scan at the cardiac time phase to acquire an echo signal from the object [in accord with the cardiac time phase], under a condition that

an applied direction of the readout gradient pulse is substantially [parallel to] in accordance with a moving direction of the fluid in motion within the object; and

image producing means for producing, from the echo signal, [an] the image [of one of] relating to the fluid [and a parenchymal portion of the object influenced by the fluid].

21. (*Amended*) The MRI system of claim [20] 60, wherein the readout gradient pulse has a main pulse [used] for reading out the echo signal and a control pulse [added to the main pulse and used] for controlling behaviors [in phase] of magnetic spins of the fluid concerning a phase of the magnetic spins, the control pulse being added to the main pulse on a time axis thereof.

23. (Amended) The MRI system of claim [20] 60, wherein the time phase setting [means is composed of mans for setting] unit is configured to set two cardiac time phases of the object,

the scanning [means is composed of acquiring] unit is configured to acquire data [consisting of] comprising two sets of echo signals by [scanning] applying first and second scans to the object [on the basis of first and second scans] at the two cardiac time phases, respectively; and

the image producing [means is composed of means for producing] unit is configured to produce an image of the fluid from the data.

25. (*Amended*) The MRI system of claim [24] 22, wherein the readout gradient pulse has a main pulse [used] for reading out the echo signal and a control pulse [added to the main pulse and used] for controlling behaviors [in phase] of magnetic spins of the fluid concerning a phase of the magnetic spins, the control pulse being added to the main pulse on a time axis thereof.

27. (*Amended*) The MRI system of claim 26, wherein the control pulse [of] belonging to the readout gradient pulse [of] in the pulse sequence used for each of the first and second scans [executed at the two cardiac time phases] is formed as a pulse responsible for at least one of the dephasing and rephasing.

28. (*Amended*) The MRI system of claim 26, wherein the control pulse [of] belonging to the readout gradient pulse [of] in the pulse sequence used for the first scan executed at one of the two cardiac time phases is formed as a pulse responsible for the dephasing and the control pulse [of] belonging to the readout gradient pulse [of] in the pulse sequence used for the second scan executed at the other cardiac time phase is formed as a pulse responsible for the rephasing.

29. (*Amended*) The MRI system of claim 28, wherein the time phase setting [means is composed of means that sets a time phase falling into a diastole of the object as] is configured to set the one cardiac time phase falling into a diastole of the object and [sets] set [another time phase falling into a systole of the object as] the other cardiac time phase falling into a systole of the object.

30. (*Amended*) The MRI system of claim 25, wherein the control pulse is changeable in [its] a wave area thereof.

31. (*Amended*) The MRI system of claim 23, wherein the scanning [means consists of means for sequentially performing] unit is configured to sequentially perform the first and second scans on either the same slice of the region or volume of the region specified by each slice encode during one time of imaging for the object [set based on one of a same slice of the object and a same slice-encode amount for the object].

36. (*Amended*) The MRI system of claim 20, wherein the fluid is a blood flow [of] within the object.

37. (Amended) The MRI system of claim 36, wherein the blood flow consists of an artery and a vein slowly flowing in an inferior limb of the object, and

the image producing [means is composed of] unit has artery/vein image producing means that produces images in which the artery and vein are shown separately.

38. (*Amended*) The MRI system of claim [24] 23, wherein each of the first and second scans [are scans] is formed based on a half-Fourier technique.

39. (*Amended*) The MRI system of claim 38, wherein the first scan [is composed of a scan depending on] carried out using a pulse sequence generating an echo

signal [in order] to map echo data in a central region of a first k-space for producing the image, the central region [forming] corresponding to a lower-frequency region in a phase-encode direction of the first k-space, and

the second scan is [composed of a scan depending on] carried out using a pulse sequence generating an echo signal [in order] to map echo data in [one] both of a central region and [both] one of both end regions other than the central region of a second k-space for producing the image, the central region [forming] corresponding to a lower-frequency region in a phase-encode direction of the second k-space and both of the end regions [forming] corresponding to a higher-frequency region in the phase-encode direction of the second k-space.

40. (*Amended*) The MRI system of claim 39, wherein the image producing [means] unit has duplicating means for duplicating echo data existing in the one end region of the second k-space to on of both end regions of the first k-space, the one end region of the first k-space being yet to be mapped with echo data, and calculating means for calculating, [with regard to] in each of the first and second k-spaces, additional echo data based on the half-Fourier technique so that the calculated additional echo data [are] is mapped into the remaining end region being yet to be mapped [in each of the first and second k-spaces for each of which the echo data are acquired with the first and second scans, respectively, and duplicating means for duplicating, into a remaining region of the first k-space in which echo data is not mapped, echo data existing in a corresponding region of the second k-space to the remaining region of the frost k-space].

41. (*Amended*) The MRI system of claim 40, wherein the image producing [means] unit includes arterial phase image producing means for obtaining one of echo data and image data representing an arterial phase image [by executing calculation] through a predetermine type of calculation executed between one of echo data of the first k-space and image data thereof and one of echo data of the second k-space and image data thereof.

42. (*Amended*) The MRI system of claim 41, wherein the predetermined type of calculation executed by the arterial phase image producing means is one of subtraction, weighted difference calculation, and addition.

43. (*Amended*) The MRI system of claim 41, wherein the image producing [means] unit includes venous phase image producing means for obtaining one of echo data and image data thereof representing a venous phase image by executing subtraction between one of echo data of image data representing the arterial phase image obtained by the arterial phase image producing means and one of echo data of the second k-space and image data thereof.

45. (*Amended*) The MRI system of claim [38] 23, wherein the pulse sequence used by each of the first and second scans is composed of a train of pulses based on one of a FASE (Fast Asymmetric SE) technique, EPI (Echo Planar Imaging) technique, FSE (Fast Spin Echo) technique, and SE (Spin Echo) technique.

46. (*Amended*) The MRI system of claim 38, wherein the time phase setting [means] unit has detecting means for detecting a signal indicative of the cardiac time phases of the object, preparing means for obtaining a plurality of MR images by executing a preparing MR sequence a plurality of times [for a] toward the region to be imaged of the object at different timings from a heartbeat reference wave appearing cyclically in the signal detected by the detecting means, and means for determining the two cardiac time phases from the plurality of MR images obtained by the preparing means.

47. (*Amended*) The MRI system of claim 46, wherein the signal indicative of the cardiac time phases is either an ECG signal [and] or a PPG signal of the object and the heartbeat reference wave is an R-wave of either of the ECG signal [and] or the PPG signal.

48. (*Amended*) The MRI system of claim 21, comprising [means] a unit for controlling an intensity of the control pulse in accord with a flow velocity of the fluid.

49. (*Amended*) An MR imaging method of obtaining an image relating to fluid within a region to be imaged of an object, comprising [the steps of]:

setting a cardiac time phase of an object;

performing, toward the region to be imaged of the object, a scan [in accord with] at the cardiac time phase with use of a pulse sequence including a readout gradient pulse

of which applied direction is substantially [parallel to] in accordance with a moving direction of fluid in motion within the object, so that an echo signal is acquired; and

producing, from the echo signal, [an] the image [of one of the fluid and a parenchymal portion of the object influenced by] relating to the fluid.

50. (*Amended*) The MR imaging method of claim [48] 49, wherein the readout gradient pulse has a main pulse to read out the echo signal and at least one of a dephase pulse and a rephase pulse responsible for dephasing and rephasing phases of magnetic spins of the fluid, respectively, the at least one pulse being added to the main pulse on a time axis thereof.

51. (*Amended*) An MRI system for obtaining an image relating to fluid within a region to be imaged of an object, comprising:

a magnet for generating a static magnetic field in which an object is placed;

an RF coil device through which an RF magnetic field is transmitted to the object and an echo signal emanated from the object is received;

a transmitter for transmitting the RF magnetic field to the object through the RF coil device, the RF magnetic field being based on a pulse sequence;

a gradient power supply for applying a gradient based on the pulse sequence to the object through a gradient coil;

a receiver for receiving the echo signal through the RF coil device, the echo signal being generated in response to performance of the pulse sequence;

a calculating unit for producing the echo signal received by the receiver into [an] the image; and

a controller for controlling operations of the transmitter, receiver and gradient power supply in conformity with the pulse sequence,

wherein the controller [executes, as the pulse sequence, a pulse sequence for a preparatory scan to set a plurality of] controls the operations of transmitter, receiver and gradient power supply so that two different cardiac time phases falling into a systole and a diastole of a cardiac cycle of the object [and a pulse sequence for] are set, and, as the pulse sequence, an imaging scan is executed in synchronism with each of the [plurality of] two different cardiac time phases in turn to acquire two sets of the echo signal, the imaging scan comprising a first scan starting at one of the two cardiac time phases falling in the systole and a second scan starting at the other of the two cardiac time phases falling in the diastole, both of the first scan and the second scan being based on a half-Fourier technique, and

the calculating unit produces [an] the image [of one of] relating to the fluid [present in a] within the region to be [scanned] imaged of the object [and a parenchymal region of the object influenced by the fluid from a plurality of] from the two sets of the echo signal acquired correspondingly to each of the [plurality of] two different cardiac time phases.

53. (*Amended*) An MRI system for obtaining an image relating to fluid within a region to be imaged of an object, comprising:

a magnet for generating a static magnetic field in which an object is placed;

an RF coil device through which an RF magnetic field is transmitted to the object and an echo signal emanated from the object is received;

a transmitter for transmitting the RF magnetic field to the object through the RF coil device, the RF magnetic field being based on a pulse sequence;

a gradient power supply for applying a gradient based on the pulse sequence to the object through a gradient coil;

a receiver for receiving the echo signal through the RF coil device, the echo signal being generated in response to performance of the pulse sequence;

a calculating unit for producing the echo signal received by the receiver into [an] the image; and

a controller for controlling operations of the transmitter, receiver and gradient power supply in conformity with the pulse sequence,

wherein the controller [executes, as the pulse sequence, a pulse sequence for a preparatory scan] controls the operations of transmitter, receiver and gradient power supply so that [to set] a cardiac time phase of the object is set and, as the pulse sequence, a pulse sequence for an imaging scan is executed in synchronism with the cardiac time phase, the imaging-scan pulse sequence including a readout gradient pulse of which applied direction being substantially [parallel] in accordance with a moving direction of fluid in motion within the object,

the calculating unit produces [an] the image [of one of] relating to the fluid [and a parenchymal region of] within the object [influenced by the fluid] from the echo signal acquired through the receiver correspondingly to performance of the imaging-scan pulse sequence.

54. (*Amended*) The MRI system of claim 53, wherein the readout gradient pulse has a main pulse to read out the echo signal and a control pulse [added to the main pulse] to control [phase] behaviors of magnetic spins of the fluid concerning a phase of the magnetic spins, the control pulse being added to the main pulse on a time axis thereof.

56. (Amended) The MRI system of claim 55, wherein the cardiac time phase [consists of] comprises two cardiac time phases falling into a systole and a diastole of the object, respectively, and

the imaging scan consists of a first scan and a second scan made to start [started] at the two cardiac time phases, respectively.